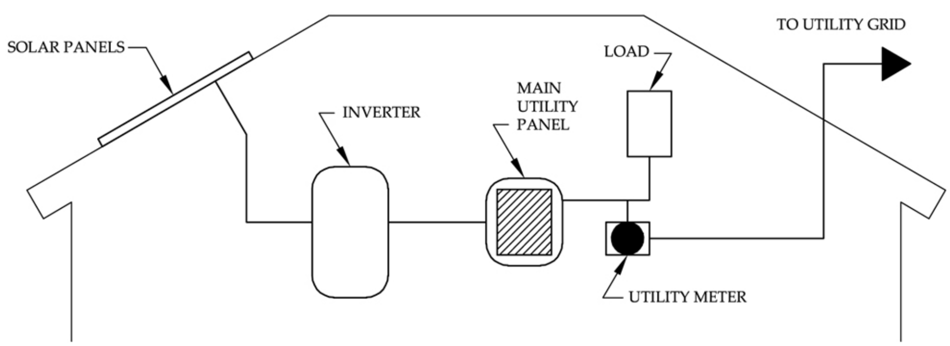
ELECTRICAL BREADTH WORK

8.1. Goals and Justification

Because the Mount St. Mary's University has shown such an interest in environmentally friendly design, a photovoltaic system for energy generation could also prove beneficial on this project. Photovoltaic (PV) modules would be located at certain locations along the south-sloping roofs and could be used to create electric energy, which could offset some of the building's costs associated with energy usage. Along with this as-yet undetermined amount of PV cells, inverters would be required convert the solar generated DC power into utility grade AC power, and from there, the AC power would be connected to the building's primary panelboard.

This arrangement would constitute a basic grid-tie system, in which the building is still connected to the electrical utility company and will use electricity from the grid as needed to compensate for the shortcomings of the photovoltaic system. Should the photovoltaic system be designed to be capable of exceeding the electrical demands of the building, the additional energy produced could then be sold back to the electrical utility company. A schematic of a basic grid-tie system can be seen in Figure 8.1.1 below.

Figure 8.1.1: Basic On-Grid Photovoltaic System



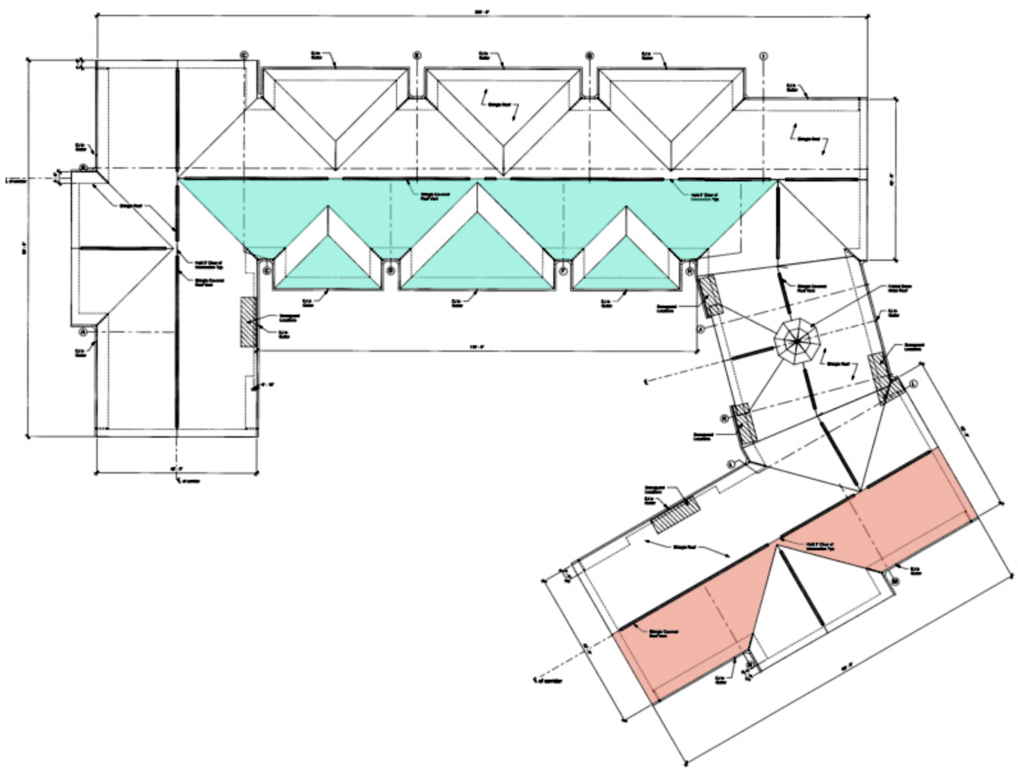
It is more likely that a photovoltaic system designed for the new dormitory at the Mount St. Mary's will only be capable of offsetting energy costs; however, most of the energy produced at this site would be during peak usage hours. This means that some portion of the building's energy costs would be mitigated during the most expensive portion of the day.

This system is one with a very high first cost. The technologies involved have not yet reached a point where there are as economically viable as other more traditional methods. Photovoltaic systems are, however, very innovative and sustainable, and many states will give incentives for their implementation. All these factors must be taken into account, as well as the potential yearly energy savings from the solar energy generation, in order to discover the feasibility of implementing a photovoltaic system into the scope of this project. In order to model this system, I will be utilizing RETScreen International's energy modeling software for photovoltaic systems.

8.2. Photovoltaic System Analysis

The new dormitory at the Mount St. Mary's University has roofs sloped at 30°, several of which are directly south facing or approximately so. In order to achieve the greatest amount of energy generation from the proposed PV panels, this south-facing orientation is greatly desired. A preliminary assessment of usable roof area is shown in Figure 8.2.1 below. The areas in blue have an azimuth of 0°, meaning they are directly south-facing, while the areas in red face slightly to the southeast and have an azimuth of 30°.

Figure 8.2.1: Available Roof Area for Photovoltaic Panels

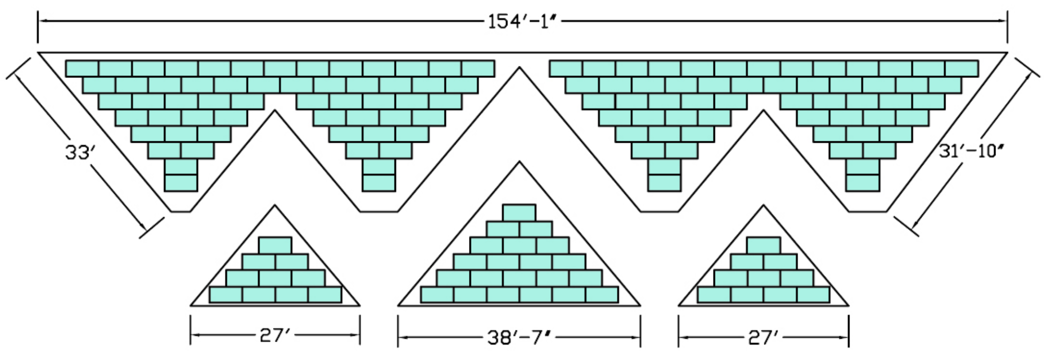


It was determined that there is 3255 ft^2 of available south-facing roof, while the additional roof area facing southeast totals 1942 ft^2. However, due to the geometric shape of the PV panels and the triangular areas of the available roof spaces, it must be determined exactly how many PV panels will most effectively occupy the usable space.

Because this company is a principal supplier of solar technologies in the Maryland area, I have chosen BP Solar's high efficiency PV modules for the project. These model BP3160 panels consist of silicon nitride multicrystalline silicone cells and are each capable of producing 160 watts of power for a warranted life of 25 years. The dimensions of a single module are 62.8 inches by 31.1 inches, and based on this size, I was able to determine the maximum number of PV panels that could realistically be used on the building's roof.

The base case I will be looking at will be covering only the south facing roof with panels, which can be seen in Figure 8.2.2 below.

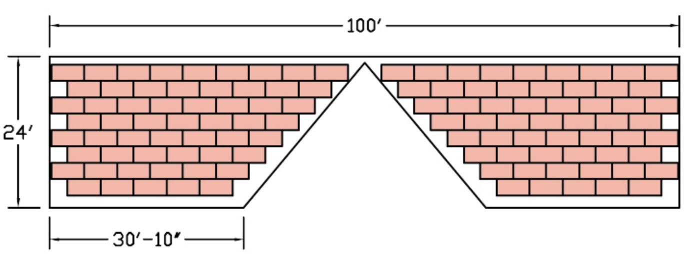
Figure 8.2.2: Base Case PV Panel Roof Coverage



It was determined here that 155 panels could be placed on the south facing roof in an aesthetically pleasing manner, which would account for 65% of the available roof area.

The alternate case I will be examining will incorporate additional panels to the southeast facing roof, which can be seen in figure 8.2.3 below.

Figure 8.2.3: Alternate Case PV Panel Roof Coverage



This roof proved capable of holding an additional 112 panels and using almost 80% of the available roof space. Even though these panels would not face directly south, they would still receive a good deal of morning sunlight and are a justifiable addition to this analysis.

RETScreen required many conditions to be set in order to analyze the photovoltaic systems. Solar data was estimated for Baltimore, Maryland as it was the closest location with yearly solar data, the slope of the panels was set to 30°, an on-grid system was specified, and manufacturer's data for BP 3160 solar panels was selected. As stated above, 155 panels were specified at a solar azimuth of 0° for the base case, and 267 panels at a modified azimuth of 12.5°, based on the ratio of south-facing panels to southeast-facing panels, were specified for the alternate case.

Cost inputs were determined by shopping around online for prevailing prices of the equipment I selected to design my system around. Based on a price of $800 dollars per panel as quoted from AdvancedEnergyOnline.com and an initial assumption of a 25% reduction in the price of the panels due to buying in large quantities, a cost of $3750/kW produced by the system was input into the program. Similarly, an inverter cost of $764/kW was input based on a price of $3820 per 5000 watt inverter from Xantrex.com. System installation was assumed to be $1500 per installed kW, inverter repair or replacement was set at 25 years, and the module support structure was estimated to be $50/m^2. All transportation costs were considered included in equipment costs, and engineering, feasibility, and developmental expenses were ignored.

For financial inputs, the debt interest rate was estimated to be 6.5% over a 15 year payback period, the avoided cost of energy was estimated to be $0.135/kWh based on the average yearly peak charges required by BG&E to purchase electrical grid energy, and the discount rate was set at 5%. There were also several state and federal grants and incentives that I found applied to my building during the course of my research. Maryland has both a Solar Energy Grant Program and a Clean Energy Incentives Act. The Solar Energy Grant Program offers reimbursement of 20% of the installed cost of commercial photovoltaic systems up to $5000. The Clean Energy Incentives Act offers state income tax credits of 15% of the installed cost up to $2000 for all photovoltaic systems. At present, the federal government is also offering solar energy tax credits of 30% of the installed cost of a photovoltaic system (after other state grants and incentives) through the end of the year 2008, by which time the new dormitory at the Mount St. Mary's University will be complete. These grants and incentives have also been incorporated into the RETScreen program.

See Appendix F for a complete set of input for both the base and alternate cases analyzed. The results of the simulation are displayed in Table 8.2.1 below.

Table 8.2.1: Base and Alternate PV System Results

Case	Nominal kW Produced	Yearly MWh	Installed Cost	Grants & Incentives	First Cost (Adjusted)	Annual Energy Savings	Payback Period (Years)
Base	24.80	33.79	$168,728	$55,519	$113,209	$4,562	28.2
Alternate	42.72	57.98	$287,894	$91,268	$196,626	$7,827	27.0

The grants and incentives offered by the state and federal governments reduce the first costs of both systems by a sizable amount, approximately 32% in each case. Still, the energy outputs of these systems are simply not good enough to justify the implementation of a photovoltaic system.

In the base case, using all available south-facing roof space, the yearly useful energy generated is 33.79 MWh. For comparison purposes, the yearly energy required to operate the building with the geothermal system was computed by HAP to be roughly 860 MWh. This base case photovoltaic system would only produce about 4% of the building's required energy requirement yearly, allowing for $4,562 in annual energy savings and 28.2 years just for a simple payback.

Similarly, in the alternate case with the addition of 112 southeast-facing panels, the yearly useful energy generated rose to 57.98 MWh. This value would account for almost 7% of the building's yearly energy requirement, save $7,827 yearly, and would still have a simple payback as high as 27 years.

With payback periods of more than 25 years for each of the proposed systems, a photovoltaic system is simply not worth incorporating into the scope of this project. Acceptable length of time for a payback on an energy saving system such as this is generally 7 years, and these systems far exceed that number. Even with government incentives, photovoltaic technology is presently just too expensive to manufacture and purchase. While the Mount St. Mary's University is very concerned about green design, they do not have the resources to add such an expensive system to the building. With a tight budget to begin with, they could never have been able to justify utilizing photovoltaic technology simple to earn a few additional LEED credits.